Effect of negative peer climate on the development of autonomous motivation in mathematics☆

Marion Reindl [a,*], Valérie-D. Berner [b], Annette Scheunpflug [c], Horst Zeinz [d], Markus Dresel [a]

[a] Department of Psychology, University of Augsburg, Germany
[b] Department of Developmental and Educational Psychology, University of Eichstätt, Germany
[c] Department of Educational Research, Otto-Friedrich-University of Bamberg, Germany
[d] Department of Educational Research, University of Muenster, Germany

1. Introduction

Different theoretical frameworks such as Self-Determination Theory (Deci & Ryan, 1985) or Expectancy-Value Theory (Eccles, 2007) have indicated the importance of domain-specific autonomous motivation for academic outcomes. Hence, strongly autonomously motivated students – specified as being more internal and autonomous than external and controlled in their behavior (Deci & Ryan, 2000) – devote more attention to tasks (Singh, Granville, & Dika, 2002; Wolters, 2004), are more oriented on mastery goals (Wolters, 2004) and demonstrate higher levels of achievement (Chen & Stevenson, 1995). Against this background, it is quite problematic that a body of research has shown significant declines in components of autonomous motivation for nearly all secondary school domains (Fredricks & Eccles, 2002; Frenzel, Goetz, Pekrun, & Watt, 2010; Gottfried, Fleming, & Gottfried, 2001; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). The decline in autonomous motivation in the subject of mathematics is particularly significant due to the demands individuals perceive in a rapidly developing technological world. Therefore, we focus on predictors that can buffer against this decline in domain-specific autonomous motivation, using the domain of mathematics as an example.

Possible explanations for the unfavorable developments in autonomous motivation can be found in pupils' social environments. Compared to the well-known effects teachers (e.g., Wentzel, 2009) and parents have on students (e.g., Eccles, 2007), surprisingly little attention has been paid to peer group influences (e.g., Berndt, 1999; Wentzel, 2005). Processes that allow peer groups to influence the development of academic motivation may result from a negative peer climate which impairs how at ease and safe students feel at school (e.g., Wentzel, 2005). Therefore, we focus on the relationship between negative peer climate and domain-specific autonomous motivation in mathematics.

1.1. Definition and development of autonomous motivation in mathematics

Autonomous motivation in mathematics is conceptualized in the context of Self-Determination Theory (Deci & Ryan, 1985, 2000) and encompasses the two motivational forms — intrinsic motivation and well internalized extrinsic motivation such as identified motivation (Vansteenkiste et al., 2010). Intrinsic motivation refers to enjoyment derived from conducting activities as a natural inclination (in the present case: for the domain mathematics). However, identified motivation focuses on the personal importance of activities. These two facets of autonomous motivation share the notion that the execution of activities is driven more by internal values (e.g., enjoyment, personal importance) than by external consequences (e.g., marks), and in turn is perceived as being more autonomous than controlled (Deci & Ryan, 2000). In contrast, if activities are conducted for the sake of external consequences, motivation is perceived as being less autonomous than controlled (Deci & Ryan, 2000).

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* Corresponding author at: Department of Psychology, University of Augsburg, Universitätsstr. 10, 86159 Augsburg, Germany. Tel.: +49 821 598 5610; fax: +49 821 598 5289.

E-mail address: marion.reindl@phil.uni-augsburg.de (M. Reindl).

Taking a developmental perspective, researchers argue that several aspects of achievement motivation decrease during the transition to, and movement through, secondary school in accord with changes in institutional and social environments (e.g., Eccles & Midgley, 1989). To the extent that relevant persons, such as teachers, parents or peers, are unable to fulfill the changing emotional and cognitive needs of a student they are, at least in part, responsible for the decline in motivation (Eccles & Roeser, 2009). Empirical evidence for declines in the above mentioned components of autonomous motivation in mathematics has been found in German and American longitudinal studies (Fredricks & Eccles, 2002; Frenzel et al., 2010; Jacobs et al., 2002).

With respect to the domain-specific focus on motivation in this study, one must consider that the magnitude of the decline can vary between different subjects (e.g., Baumert & Köller, 1998). Therefore, students can develop their own preferences for specific topics; this is also reflected in significant variations in the magnitudes of changes in the domain of mathematics (Fredricks & Eccles, 2002; Frenzel et al., 2010). Possible explanations can be found in social environments, e.g., parents, peers or teachers, as well as in individual conditions, e.g. academic self-concept (e.g., Eccles, 2007). With respect to social environments, gender socialization processes provide one possibility (e.g., Eccles, 1984). As such, parents, peers or teachers consider abilities in mathematics to be more important for boys than for girls. Empirical results support this assumption by indicating that the dimensions of autonomous motivation in mathematics decrease more profoundly for girls than for boys (Frenzel et al., 2010; Jacobs et al., 2002). With regard to individual conditions, academic self-concept as the evaluation of one's own academic abilities (Shavelson, Hubner, & Stanton, 1976) influence students' values concerning academic domains. Empirical results also support the position that higher academic self-concept is linked to higher personal importance and positive feelings concerning a specific domain (Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005; Spinath & Steinmayr, 2008). Nonetheless, the explained variance for both is small on the individual level (Fredricks & Eccles, 2002; Frenzel et al., 2010). Thus, it could be fruitful to look for stronger predictors on the classroom level to better explain the change in autonomous motivation. Thus, we turn to classroom climate in the following.

1.2. Negative peer climate

Fundamental in establishing a specific classroom climate – defined as the quality of interaction processes within the classroom (Eder, 1996) – are two socialization agents who are available to participate in classroom interaction processes, namely teachers and peers. Previous research has impressively demonstrated that teachers and their social and instructional behavior affect students' perceptions of the overall classroom climate to a considerable degree (e.g., Jang, Kim, & Reeve, 2012; Kiuru et al., 2012). In contrast to the relatively broad research on how teachers establish a classroom climate and its consequences for student motivation, prior research has not accorded the peer group much attention. Yet, it is important to take into account that, in many domains, peers become important socialization agents in early adolescence (Brown & Larson, 2009). Therefore, we adopt this assumption for the prediction of motivational outcomes in the academic area.

The peer context is defined in the present work as the entire classroom community because all students grouped in a classroom are potential interaction partners. In many school systems classmates remain constant across most of a pupil's subjects and throughout the course of his/her secondary school years (as it is in the German school system). Therefore, the entire classroom community is expected to have an influence on individual students' motivational outcomes.

Some empirical evidence already shows that the classroom community influences motivational dimensions, as evidenced by studies focusing on achievement goals (Nelson & DeBacker, 2008) or interest (Wentzel, Battle, Russell, & Looney, 2010). Theoretical explanations are provided by Self-Determination Theory (Deci & Ryan, 1985, 2000). This framework can explain how the fulfillment of three basic needs can facilitate the development of motivation through person–environment interactions: specifically the needs for autonomy, competence and relatedness (Deci & Ryan, 1985, 2000). Hence, students should perceive themselves as the origin of their own behavior and believe their behavior to be effective. In order to explain the influence of a negative peer climate we focus on the basic need for relatedness — or the feeling of being connected and accepted by a group (e.g. Wentzel, 2009). This feeling can be initiated in the school context through forms of emotional as well as instrumental support (see Wentzel, 1998). With regard to the creation of a negative peer climate, negative experiences regarding these two aspects can be assumed to be particularly relevant. In particular, when students feel rejected in the classroom, i.e. are strongly disliked by other group members (Bukowski & Hoza, 1989) and a predominance of a strong competitiveness exists, i.e. many students focus on their own benefits (e.g. Wentzel, 2009), inter-individual interactions are primary characterized as non-supportive. The existence of both aspects, rejection and non-cooperation, can be seen as a buffer for sharing positive feelings in a specific domain (e.g., in learning groups, mutual affirmation etc., Wentzel, 2009) and in turn facilitate a positive development of motivational outcomes (Deci & Ryan, 2000; Eccles & Roeser, 2009). There is also empirical evidence that a negative peer climate is closely linked to lower personal importance and fewer positive feelings concerning the domain (Buhs, Ladd, & Herald, 2006; Wentzel, 2009).

1.3. Investigation of climate variables on different aggregate levels

All previously mentioned studies have focused on the perception of a negative peer climate exclusively on the individual level. Thus, they did not take into account that a negative peer climate is established by inter-individual interactions with many classmates and is thus a construct primarily located at the classroom level (e.g., Eder, 1996; Marsh et al., 2012). Correspondingly, Marsh et al. (2012) stated that when considering a collective classroom climate one should take into account that, theoretically, every pupil in a classroom is exposed to the same classroom climate as their classmates. Therefore, the construct of classroom climate is primarily reflected in a shared perception of the climate rather than an individual perception by each pupil in the classroom. Actually, previous studies focusing on collective climate variables found large classroom level variances (Ditton & Krecker, 1995; Eder, 1996). This is an important prerequisite for analyzing the effects of classroom characteristics (in the present case: negative peer climate) on the development of individual characteristics (in the present case: autonomous motivation in mathematics).

1.4. Present study

Our primary objective was to investigate how a negative peer climate in the classroom is related to the development of autonomous motivation (even when important predictors, such as marks and gender, are controlled for). Due to the lack of longitudinal studies in this area, we investigated the predictor effects from a developmental perspective, using the domain of mathematics as an example.

First, we focused on the development of autonomous motivation in mathematics. In accord with theoretical explanations (e.g., Eccles & Midgley, 1989) and empirical results (Fredricks & Eccles, 2002; Frenzel et al., 2010; Jacobs et al., 2002), we expected a decline in student autonomous motivation in mathematics over the course of secondary school (Hypotheses 1). Furthermore, we expected that the development of autonomous motivation would vary between classrooms (Baumert & Köller, 1998; Hypotheses 2). The final and decisive step involved the prediction of developmental variations in autonomous motivation through negative peer climate (Deci & Ryan, 2000; Eccles & Roeser, 2009). Here, we expected that a strong negative peer climate would compound a decline in autonomous motivation in mathematics (Hypotheses 3).

2. Method

2.1. Procedure and participants

To meet the present research objectives we drew on data collected in a more comprehensive German longitudinal study with three measurement points. The participants were 4100 public secondary school (Realschule) students in grades 5 through 10.[1] To test our hypotheses concerning the development of autonomous motivation in early adolescence, we selected those students who were in grades 5 or 7 grade levels at Time 1 and had participated in the first longitudinal wave. In the school type under investigation pupils are assigned to new classrooms following the 6th grade (due to subject specializations). We excluded 6th graders from our study because one of the requirements for investigating the influence of climate variables was that students had to remain in the same classroom community over the two-year course of the investigative period. Students in grades 8, 9 and 10 at Time 1 were also excluded. This decision was made for two reasons: First, we would not be able to schedule three measurement occasions with equivalent time lags over a period of two years for students in the 9th and 10th grades. Second, the 8th through the 10th grades would have had at least one assessment point in 10th grade, the grade at which graduation occurs. It is expected that the specific decision making processes concerning one's future life associated with this structural component, as well as the underlying motivational processes, would influence the development of autonomous motivation for these students. Consequently, the sample used for the present analyses comprised 1082 students in 39 classrooms (668 in 5th grade, 414 in 7th grade at Time 1; 569 girls and 513 boys). On average, 27.4 students from each of the 39 classrooms participated. Students' mean age was 11.7 years at Time 1 ($SD = 1.14$).

The measurements were scheduled at least two weeks after the beginning of the initial school year (Time 1), 12 months later in the transition to the next grade level (Time 2)[2] and again 12 months later (Time 3). The drop-out rate between Time 1 and Time 2 was 10.6%, and the drop-out rate between Time 2 and Time 3 was an additional 10.5%. In total, 80.0% of the final sample of the students participated in all three measuring sessions. Autonomous motivation, negative peer climate and personal characteristics were assessed at all three measurement points using paper–pencil questionnaires. The data were collected during regular classroom instruction periods.

2.2. Measures

We used established measuring instruments to assess domain specific autonomous motivation and negative peer climate (instruments that had already been used in several large scale assessments such as PISA; e.g. Kunter et al., 2003). To control for potential subject specializations associated with adolescence (e.g., Baumert & Köller, 1998), a domain specific focus for motivation was used to ensure the validity of the conclusions; consequently we chose the domain of mathematics. The construct of negative peer climate was assessed in general (i.e. without reference to a specific school subject) since in the German school system one's classmates remain constant over different subjects. The summary statistics, correlations and internal consistencies of the respective dimensions are presented in Table 1.

[1] The German school system consists of several tracks for secondary education. Following elementary school (fourth grade), students are assigned to one of three major school tracks according to ability. These are one higher, college-bound school track (Gymnasium) and two more vocationally oriented lower school tracks (Realschule and Hauptschule).

[2] At T2, 141 students were assessed at the end of the same school year in which the first measurement occasion (beginning of the school year) was scheduled.

2.2.1. Autonomous motivation in mathematics

Domain specific autonomous motivation for mathematics was assessed at all three measurement points with three items (Kunter et al., 2003). The scale used is a well-established instrument for assessing dimensions such as enjoyment and personal importance. We used this instrument to assess the specific components of autonomous motivation economically. The scale focuses on intrinsic motivation like enjoyment with two items ("Because doing mathematics is fun, I don't want to abandon it" and "when doing mathematics I forget everything around me") and the central aspect of identified motivation, for instance the personal importance of the activity, was assessed with one item ("mathematics is important to me"). The items were assessed along a 4-point Likert-type scale ranging from 1 (*strongly disagree*) to 4 (*strongly agree*). The internal consistencies were good at all three measuring points.

2.2.2. Negative peer climate

To assess negative peer climate we used an established German questionnaire (Helmke, 1979). Corresponding to the theoretical definition of negative peer climate, the scale captures the degree to which students feel rejected by their classroom community in general (sample item: "In our classroom you can become an outsider really fast if you don't do what the class does") and the degree to which students perceive a predominance of non-cooperation in the classroom context ("In our classroom everybody is bent on his own advantage when it comes down to good marks"). The applied version consisted of five items which can be found in Appendix A. With the explicit pronunciation of the classroom context in every single item, the instrument primarily can be seen as a classroom specific estimation of negative peer climate (Marsh et al., 2012). The items were presented alongside a 5-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). To gain a more valid estimation of the environment (classroom climate) and reduce the measurement errors stemming from a single measuring point, we specified this variable as a latent time varying construct (intercept of all three measurement points, see also Wang & Eccles, 2012). Especially in the case of the 5th graders, where the classmates had already had initial experiences with their new classmates (for at least two weeks), this method heightens the validity for assessing the real classroom climate. The scales demonstrated a good internal consistency for all three measuring points ($\alpha = .83$–$.89$).

2.2.3. Control variables

On the individual level, gender served as a control variable. Additionally, the self-reported report card was used to control for prior academic achievement. The reported marks refer to the students'final marks in their previous grade level in mathematics and represented the normative evaluation of one's own competence (e.g., Eccles, 2007). Moreover, students' grade levels were integrated to control for variance in the decline between different age-groups.

2.3. Analysis

All models were estimated using Mplus 6 (Muthén & Muthén, 2010). We specified doubly latent two-level multiple indicator growth-curve models (Marsh et al., 2012; Muthén, 1997) for three reasons: First, the full potential of longitudinal data can be best addressed in growth curve models with which inter-individual differences in change over time are modeled (slope; Little, Card, Preacher, & McConnell, 2009; McArdle & Epstein, 1987). Second, the multiple indicator approach allows one to control for measurement errors in the constructs of interest (Muthén, 1997). Third, the doubly latent approach for nested data structures additionally allows one to control for sampling errors when modeling climate variables on the cluster level (Marsh et al., 2012).

According to the multiple indicator approach (Muthén, 1997), the specification of linear changes requires latent variables for autonomous motivation at each measuring point. These were specified with the respective means of the manifest indicators (three items). Regarding

Table 1
Summery statistics and zero-order correlations.

	M	*SD*	α	1	2	3	4	5	6	7
Individual level										
1. Motivation T1	2.71	0.72	.80							
2. Motivation T2	2.46	0.83	.82	.59						
3. Motivation T3	2.26	0.83	.82	.48	.57					
4. Negative peer climate[a]	2.87	0.57	.86	.17	.21	.23				
5. Gender	–	–	–	−.31	−.25	−.29	−.31			
6. Prior achievement	–	–	–	−.39	−.31	−.32	−.09	.17		
Classroom level										
7. Grade level	–	–	–	−.44	−.18	.51	–	–	–	
8. Negative peer climate[a]	2.87	0.23	.86	−.29	−.34	−.40	–	–	–	−.04

Note: Motivation = autonomous motivation in mathematics. Control-variables are specified only for the respective level; therefore they were correlated only with variables within the levels. Results of means and standard deviations are from *Unconditional means model.*
All correlations within $|r| \geq .10$ were significant ($p < .01$), all correlations between $|r| \geq .40$ were significant ($p < .05$),
[a] Negative peer climate is specified with the respective intercepts of all three measuring points as an average climate variable.

negative peer climate, the intercepts at each measuring point were specified with the respective items and served as three manifest indicators.

One requirement for the specification of linear changes with latent variables is measurement invariance over time (Schmitt, Golubovich, & Leong, 2011). This test was conducted for the indicators of autonomous motivation in three steps. The first step was a test of configural invariance. The factor-loadings, intercepts and co-variances were subsequently estimated without any restrictions. The model showed a very good fit, χ^2 (15, n = 1038) = 30.72, p = .01, RMSEA = .03, SRMR = .02, CFI = .99, TLI = .99, which indicated configural invariance. In the second step, metric invariance was tested by setting the factor loadings to be equal across measurement occasions. This did not result in a significant decrease in model fit,[3] *TRd* (df = 4) = 0.31, p = .99, indicating metric invariance. The third step targeted scalar invariance. As with the factor-loadings, the intercepts were set to be equal across measurement occasions. Setting all of the intercepts to be equal resulted in a significant decrease in model fit, *TRd* (df = 4) = 17.04, p = .002. In accord with the suggestions by Byrne, Shavelson, and Muthén (1989) for this common case, we then constrained only the first intercept to be equal. The resulting model did not show a worse fit than the metric invariance model, *TRd* (df = 2) = 3.55, p = .17, indicating partial scalar invariance that also allows for the interpretation of changes in the means.

With respect to the nested data structure, the final models were specified by a doubly latent multilevel approach. For this purpose, the restrictions of the latent variables (autonomous motivation) were kept across the levels so as to ensure invariant constructs on both levels (Marsh et al., 2012). Additionally, the factor loadings and intercepts of negative peer climate were fixed across the levels. Based on the assumption that students in a single classroom are not independent from one another (Raudenbush & Bryk, 2002), individual and classroom level variance components were modeled.

In order to ensure the reliability of the latent variables on the classroom level, we initially specified a model including all latent constructs (autonomous motivation at each measuring point and negative peer climate) and all correlations between them (*Unconditional Means Model*, Fig. 1). Based on this model, we estimated the intra-class correlation ICC(1) as the proportion of the between-classroom differences in the total variance. With regard to these results, the reliability of the constructs on the classroom level, ICC(2), can be estimated (Bliese, 2000). Founded on the highly internal consistency of the constructs, we specified the next model to estimate the average change (Hypothesis 1) as well as the variance in the slope (Hypothesis 2) of domain specific autonomous motivation on the classroom level (ICC(1); *Unconditional Growth Model*, see Fig. 1). Thus, in linear change models, intercepts depicting the adolescents T1 value on the respective variable and a slope variable were specified.

The third model involved the prediction of the variance components of the slope of autonomous motivation in mathematics through negative peer climate (Hypothesis 3) controlling for gender (0 = male, 1 = female) and marks (1 = very good to 6 = very bad) on the individual level, and grade level (0 = grade 5, 1 = grade 7) on the classroom level (*Slope as Outcome Model*). The climate variable was grand-mean centered — consequently, the respective coefficient refers to the partial effect of the classroom level variable (collective climate) controlling for the individual effect (subjective part of the climate perception; Marsh et al., 2012).

2.4. Dealing with missing data

Missing values proved to be completely at random, Little's MCAR test: χ^2 (5) = 9.71, p = .08. This result allows for an estimation of the missing values through the Full Information Maximum Likelihood method (Finkenbeiner, 1979; Schafer & Graham, 2002). Compared to a pair-wise or list-wise deletion of incomplete cases, this method reduces potential biases due to attrition in longitudinal analyses (Schafer & Graham, 2002).

3. Results

3.1. Basic model of classroom differences

The *Unconditional Means Model* showed a good fit, χ^2 (110, n = 1083) = 267.15, p < .001, RMSEA = .04, SRMR (*within*) = .03, SRMR (*between*) = .10, CFI = .97, TLI = .96. Both negative peer climate and autonomous motivation varied considerably at each measuring point on the classroom level (Table 2). Moreover, ICC(2) indicated that the constructs are reliably observed through the different student perceptions.

Also the *Unconditional Growth Model* fit the data well, χ^2 (116, n = 1083) = 283.07, p < .001, RMSEA = .04, SRMR (*within*) = .03, SRMR (*between*) = .11, CFI = .97, TLI = .96. We found a significant decline in domain-specific autonomous motivation, which indicated an average decrease in autonomous motivation in mathematics over the course of two years (Table 3). Additionally, substantial differences between classrooms were found in the change of autonomous motivation over time: 35.6% of the slope variance was located on the classroom level.[4]

3.2. Effects of negative peer climate

The *Slope as Outcome Model* demonstrated a sufficient fit, χ^2 (150, n = 1083) = 438.73, p < .001, RMSEA = .04, SRMR (*within*) = .07,

[3] Due to the multilevel approach and the obtained MLR-estimator in Mplus, the models were compared with a scaled difference test (*Trd*; Satorra, 2000; Satorra & Bentler, 2001).

[4] This proportion of variance results from dividing the between classroom variance (classroom level) of the slope by the total variance of the slope (classroom level and individual level).

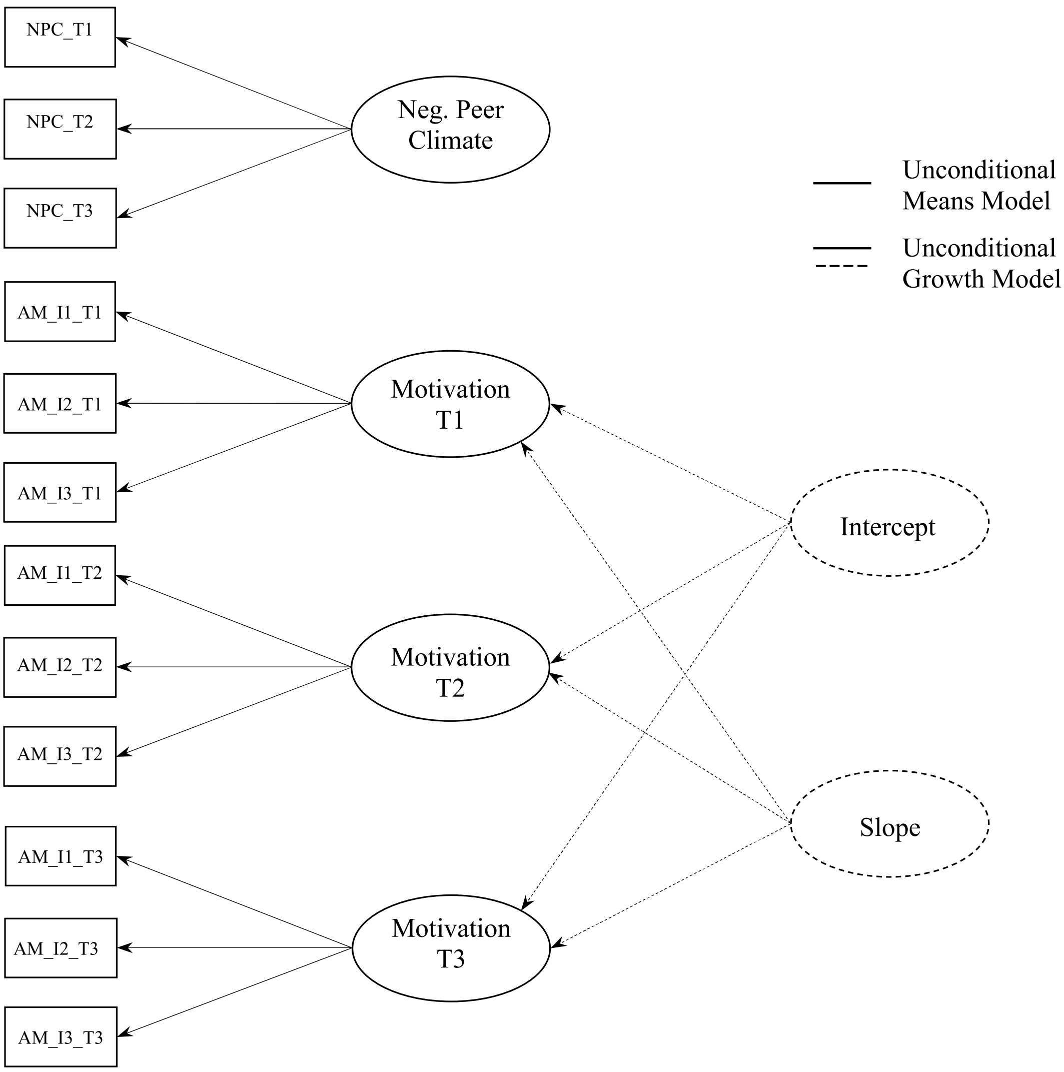

Fig. 1. Measurement model without intercept and slope (*Unconditional means model*); Final measurement model including intercept and slope (*Unconditional growth model*); manifest indicators: NPC = negative peer climate, AM = autonomous motivation; I1 = Item 1; I2 = Item 2; I3 = Item 3; T1 = first measurement occasion; T2 = second measurement occasion; T3 = third measurement occasion; all covariances between latent variables were estimated; error terms are not depicted in this figure.

SRMR (*between*) = .14, CFI = .94, TLI = .94. As expected, negative peer climate had a significant negative effect on the development of autonomous motivation in mathematics on the classroom level (see Table 3). The stronger the average negative peer climate in the classroom was, the stronger was the decline in individual students' autonomous motivation in mathematics over time. However, on the level of individual perceptions, negative peer climate had no significant effect on autonomous motivation. To better understand the classroom effect, we calculated the average development of autonomous motivation for three different negative peer climate values ($M + SD$, M, $M - SD$; Fig. 2). This demonstrated that for a strong negative peer climate the autonomous motivation in mathematics decreased substantially. In contrast, a weak negative peer climate buffered against the decline and autonomous motivation remains just about constant.

Table 2
Unconditional means model.

	Unconditional means model			
	Negative peer climate[a]	Motivation T1	Motivation T2	Motivation T3
Variance components				
Individual level	0.326	0.525	0.681	0.694
Classroom level	0.055	0.141	0.069	0.068
ICC(1)	.14	.21	.09	.09
ICC(2)	.82	.88	.73	.73

Note: Motivation = autonomous motivation in mathematics.
[a] Negative peer climate is specified with the respective intercepts of all three measurement points as an average climate variable.

Concerning the control variables on the individual level, gender had a significant effect on the development of domain-specific autonomous motivation in mathematics. As expected, autonomous motivation in mathematics decreased more substantially for girls than for boys. In contrast, prior achievement did not have an effect on the development of autonomous motivation. On the classroom level, grade level had a significant effect on the development of autonomous motivation. Accordingly, autonomous motivation declined more intensely at the beginning of secondary school (5th grade) than in the middle of it (7th grade).

4. Discussion

The present study focused on the development of domain-specific autonomous motivation in mathematics and peer group influences on these developments. In line with our expectations and existing results (Fredricks & Eccles, 2002; Frenzel et al., 2010; Jacobs et al., 2002), we found a linear decline in students' autonomous motivation in the subject

Table 3
Unconditional growth model and slope as outcome model.

	Unconditional growth model		Slope as outcome model	
	Beta	SE	Beta	SE
Individual level				
Intercept	2.69**	.07	2.69**	.07
Intercept slope	−.22**	.03	−.32**	.06
Negative peer climate			.05	.04
Prior achievement			.03	.02
Gender			−.13**	.05
Classroom level				
Negative peer climate			−.22*	.10
Grade level			.27**	.04
Variance components (slope)				
Individual level	0.038		0.032	
Classroom level	0.021		0.004	
Variance explained (slope)				
Individual level			0.14	
Classroom level			0.84	

Note: Effects are unstandardized beta coefficients. The ICC(1) for the slope of autonomous motivation in mathematics is calculated based on the variance components of *Unconditional growth model*.
* $p < .05$.
** $p < .01$.

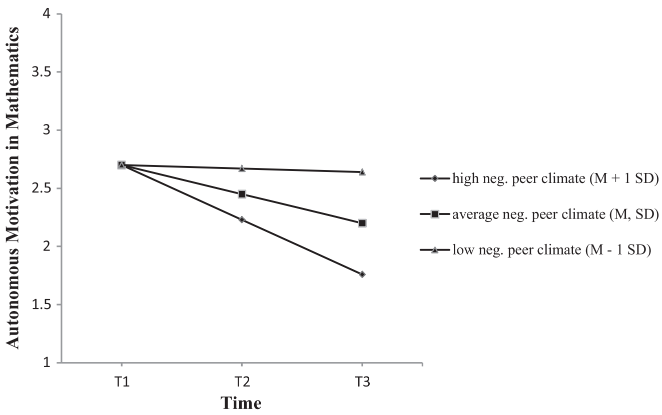

Fig. 2. Growth curves for the development of autonomous motivation in the subject of mathematics in dependence on negative peer climate over two school years (including 5th and 7th grade level). It's expected that negative peer climate explains the variance in the change of autonomous motivation over the course of two school years and not the variance at the beginning of the classroom compositions (initial status). Therefore, the students do not vary in the initial status (T1) according to negative peer climate.

of mathematics (Hypothesis 1). Moreover, we identified substantial variance between classrooms in motivational developments (Hypothesis 2). Students from different classrooms lost their autonomous motivation in mathematics, averagely, to different degrees. This finding supports the assumption that there are also variations in the social environment, e.g. in the extent to which the need for relatedness is satisfied, which can be responsible for this variance.

With respect to these variations in the social environment, we were able to show that classmates influence domain-specific motivation, i.e. that a negative peer climate has a negative effect on the development of autonomous motivation in mathematics on the classroom level (Hypothesis 3). This finding corresponds with theoretical explanations (Deci & Ryan, 2000) and empirical results from prior cross-sectional studies (Nelson & DeBacker, 2008; Wentzel et al., 2010) regarding variations in the fulfillment of the basic need for relatedness and the impact on personal importance and positive feelings for specific school-subjects. More precisely, a negative peer climate which is characterized by rejection and lack of cooperation in the classroom can be associated with reduced learning opportunities, for instance learning groups. Thus, the absence of interpersonal processes to share personal values about a domain can in turn result in lower personal importance and fewer positive feelings for that domain. As the climate was measured without reference to a specific subject, it seems reasonable to argue that it has a negative impact on any subject.

In contrast to the classroom effect, the effect of negative peer climate on the level of individual perceptions (i.e. effects of the individual perceptual deviation from the shared perception in the classroom) was not significant. Following the argumentation by Marsh et al. (2012), the individual perceptual deviations from the dominant shared perception in the classroom could be interpreted primarily as a source of unreliability in classroom climate constructs and are, therefore, not expected to have substantial effects. This applies in the present case since the item texts in the instrument used focus more on the shared perception rather than one's own perception of the climate in the classroom. Also, with regard to this argumentation, the results of cross-sectional studies (Nelson & DeBacker, 2008; Wentzel et al., 2010) – using instruments focusing more on individual perceptions – are limited because they only investigated the effect on an individual level.

In agreement with earlier findings on gender differences (e.g., Fredricks & Eccles, 2002; Frenzel et al., 2010; Jacobs et al., 2002), we found that autonomous motivation in mathematics declined less for boys than for girls. One explanation can be found in the social environment and underlying gender socialization processes (Eccles, 1984). However, in line with existing results, the gender effect was not that strong. Therefore, we assume that gender plays more of a subordinate role for the socialization of academic motivation in mathematics.

Students' marks did not influence changes in autonomous motivation in mathematics. Similarly, previous studies found small effects on the change in motivational outcomes at best (Marsh et al., 2005; Spinath & Steinmayr, 2008), indicating that external consequences, like marks, have no significant influence over whether or not engagement with mathematics results from autonomous motivation.

In agreement with another study in the German context (Frenzel et al., 2010), we found that the decline in autonomous motivation was smaller in higher grade levels. In contrast, in school systems like the U.S., no such trend is apparent (Jacobs et al., 2002). Possible explanations may be found in differences between the school systems. In Germany students spend most of their time learning in one consistent classroom community, and therefore have more opportunity to adjust to their classmates and create a basis for them to influence autonomous motivation. In contrast, the U.S. course system requires a flexible adaption to new classmates, which reduces the possibility of adapting and, in turn, the buffering effects peers may otherwise have.

4.1. Limitations and future directions

Despite the focus on peers at the classroom level, some earlier studies investigated the influence of close friends on a second level and found effects for their support (Murdock & Miller, 2003; Wang & Eccles, 2012). To gain a more sophisticated understanding of peer group effects, future studies should distinguish between close friends and the entire classroom community as different social sources. Furthermore, in the present study we focused exclusively on the peer context. It is obvious that teachers and their support also play an important role in establishing the overall classroom climate and in facilitating motivational outcomes (Jang et al., 2012; Kiuru et al., 2012). Thus, focusing on interaction processes between classmates and teachers could provide insightful information on how the two groups of important others facilitate the development of autonomous motivation through additive or compensatory effects.

We examined school grades with pupils in early-adolescence because it can be assumed that peer influences are especially strong in this developmental period. Taking into account that with increasing age adolescents may well switch their focus, especially concerning social values (Fuligni & Stevenson, 1995), the influence of peers on school values, such as those towards mathematics, may also decrease.

Moreover, we assessed negative peer climate by using student perceptions rather than an objective estimation. This method seems reasonable because personal perceptions of each student in the classroom, and the aggregation of these data, are seen as valid estimations of the true classroom climate (Marsh et al., 2012) and, in turn, more relevant for one's own motivation in comparison to using other informants (e.g. teacher reports of negative peer climate). Nonetheless, objective observational instruments could provide additional information on the effects of climate aspects on students' motivation.

For the assessment of autonomous motivation we used a combined measurement of intrinsic motivation (two items) and identified motivation (one item). It could be beneficial to assess the two motivation types separately. This could also allow for the investigation of internalization processes (from identified to intrinsic motivation) and their antecedents.

Finally, our sample was limited to German students. One cannot guarantee that the reported results are cross-culturally valid due to differences in educational systems across countries (e.g., with regard to the organization of stable classroom communities or individual courses).

5. Conclusions

Despite these limitations, the present study allows one to derive conclusions towards a more differentiated understanding of peer influences on academic motivation. In sum, we conclude that negative peer climate has a substantial influence on the development of domain specific autonomous motivation (here: in mathematics). Considering the relevance of autonomous motivation for academic outcomes, this finding seems to be even more important. It seems reasonable to assume that peers can also facilitate indirectly (mediated through autonomous motivation) students' levels of task engagement and achievement. To identify the full concert of the effects peers have on academic learning, future studies should also address these possible mediation effects as well as different social environments such as simultaneously analyzing teacher and parental influences in relation to the influences of peers.

Appendix A

Items on the final questionnaire to assess the perceived negative peer climate:

1. In our classroom everybody is bent on his own advantage when it comes down to good marks.
2. In our classroom you can become an outsider really fast if you don't do what the class does. 3. In our classroom everybody tries to get better marks than the others.
4. Many classmates are sometimes jealous when other classmates get better marks than they do.
5. In our classroom there are some students who get little attention from the others.

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